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On the run: free-living mushroom corals avoiding interaction with sponges

B. W. Hoeksema · N. J. de Voogd

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Abstract Individuals of the free-living mushroom coral *Heliofungia fralinae* moved away when placed in contact with fragments of the toxic haplosclerid sponge *Callyspongia (Euplacella) biru*. This reaction was not evoked by three other sponge species. The experiment demonstrated that mobility of mushroom corals helps them to flee from organisms that secrete secondary metabolites in competition for space.

Keywords Competition · Interspecific aggression · Mobility · Toxicity

Introduction

Various groups of coral reef organisms employ interspecific aggression in competition for space. Scleractinian corals may come into contact with other organisms, such as algae (River and Edmunds 2001; Jompa and McCook 2002, 2003; Nugues and Bak 2006; Haas et al. 2010; Benzoni et al. 2011), ascidians (Bak et al. 1981, 1996; Sommer et al. 2009), barnacles (Benzoni et al. 2010), corallimorpharians (Chadwick 1991; Chadwick and Adams 1991; Langmead and Chadwick-Furman 1999; Kuguru et al. 2004), polychaetes (Samini Namin et al. 2010), soft corals (Sammarco et al. 1983; Dai 1990), and particularly by sponges (de Voogd et al. 2004, 2005; Coles and Bolick 2007; de Voogd 2007; Benzoni et al. 2008) and may be overgrown and even killed by them. Scleractinian coral species also show aggressive reactions to one another, which may depend on coral size, secretion of bioactive compounds, and the presence of sweeper tentacles (Sheppard 1981; Bak et al. 1982; Koh and Sweatman 2000; Lapid et al. 2004; Lapid and Chadwick 2006; Chadwick and Morrow 2011).

Mushroom corals (Fungiidae) usually play the role of aggressor in interspecific coral interactions (Sheppard 1979; Cope 1981; Thomason and Brown 1986; Chadwick 1988; Chadwick-Furman and Loya 1992; Abelson and Loya 1999). They are not known to damage each other but when they overtop each other in multi-species assemblages (Hoeksema and Moka 1989; Hoeksema 1991; Elahi 2008; Hoeksema and Koh 2009; Hoeksema and Matthews 2011), they may compete for space, light and food. The chance for frequent contact with other organisms, such as sponges, is especially high in free-living fungiids, which detach themselves from the substrate and become mobile (Chadwick 1988; Hoeksema 1988; Chadwick-Furman and Loya 1992; Yamashiro and Nishihira 1995; Hoeksema and Yeemin 2011). Sponges may produce toxic compounds that play an important role in competition for space with scleractinian corals (Aerts and van Soest 1997; de Voogd et al. 2004). Some species of sponges can also harm corals by overgrowing them or by boring into them (Aerts 1998; Schönberg and Wilkinson 2001; de Voogd et al. 2004, 2005; López-Victoria et al. 2006; González-Rivero et al. 2011). Here, we examined the consequences of free-living mushroom corals being forced into contact with fragments of a range of sponge species with varying degrees of toxicity.

Materials and methods

The study site was at the reef base on the northwest side of Samalona I. (05°07.326′S 119°20.410′E) in the Spermonde

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B. W. Hoeksema (✉) · N. J. de Voogd
Department of Marine Zoology, Netherlands Centre for Biodiversity Naturalis, P.O. Box 9517, 2300 RA Leiden, The Netherlands
e-mail: bert.hoeksema@ncbnaturalis.nl

Archipelago, 7 km off Makassar, SW Sulawesi, Indonesia. Mushroom corals and sponges are diverse in this area (Hoeksema and Moka 1989; Cleary et al. 2005; Becking et al. 2006; de Voogd et al. 2006). Four sponge species were selected on the basis of their abundance and known bioactivity (de Voogd 2005; de Voogd et al. 2006; Cleary and de Voogd 2007). In order of decreasing bioactivity of crude extracts, the target species were *Callyspongia biru* de Voogd, 2004 > *Amphimedon paraviridis* (Fromont, 1993) > *Niphates olemda* (De Laubenfels, 1934) > *Aaptos suberitoides* (Brøndsted, 1934) (de Voogd 2005).

The free-living mushroom coral *Heliofungia fralinae* (Nemenzo, 1955) was chosen as potential spatial competitor. This species is able to move across the reef surface and commonly reproduces asexually by budding which may result in dense aggregations that cover the substrate to the exclusion of other reef organisms (Hoeksema 1990, 2004).

In June 2001, 14 similarly sized fragments (length 10–12 cm) of each sponge target species were collected at a depth of 12 m. Thin plastic-coated electric cable was used to attach them to nylon fish net stretched over a 100 × 70 cm rectangular frame of PVC tubes (Fig. 1a). After an adjustment period of 10 weeks, 40 individuals of *H. fralinae* (∅ 12–15 cm) were collected. Ten corals were tied closely next to an equal number of sponge fragments attached to PVC-frames with cable to keep the coral and sponge in direct contact with each other (Fig. 1). Two complete fragments per sponge species were collected at the start of the experiment and two control fragments were left on the frame without contact with corals until collection at the end of the experiment. The fragments of each sponge species were scheduled to be collected for toxicity tests, two at each of five times over the experiment: T1 = 24 h, T2 = 48 h, T3 = 7 days, T4 = 14 days, and T5 = 21 days. The toxicity test was designed to see whether forced contact with a spatial competitor would cause a change in toxicity of the sponges (e.g., Richelle-Maurer et al. 2003).

Changes in bioactivity of the crude extract of the *Callyspongia biru* fragments were assessed using the brine shrimp (*Artemia salina*) lethality test. This is an effective assay for bioactive activity of secondary metabolites from terrestrial and marine organisms (Meyer et al. 1982) and can be used when alternative bioassays are not available (Caldwell et al. 2003). Brine shrimp larvae are known to be sensitive to crude sponge extracts (Richelle-Maurer et al. 2002).

The crude extract of the sponge was obtained as follows: sponge fragments were cut in small pieces and extracted in ±50 ml methanol for 24 h; this was repeated three times. The filtrates from each species were combined and placed in a cooled evaporator for approximately 48 h. The bioactivity of the resulting extract was expressed with the LC_{50} (mortality of ≥ 50% *Artemia* nauplii after exposure to dilutions of the crude extract of *C. biru*; see de Voogd 2005). Bioactivity was based on five categories: very strong = LC50 ≤ 1 mg l^{-1}, strong = LC50 between 1 and 5 mg l^{-1}, moderate = LC50 between 5 and 10 mg l^{-1} and weak = LC50 between 10 and 20 mg l^{-1}.

Results and discussion

After 24 (T1) and 48 h (T2), two of the complete sponge fragments were collected from the frames for toxicity measurements, while the corals were placed back on the reef. After 7 days (T3), five of the six remaining mushroom corals that had been in contact with *C. biru* had freed themselves from the cable and moved away, thereby terminating the experiment (Fig. 1b). The corals moved ca. 5–20 cm away from the sponges. One of the corals had even moved off the frame. The crude extract from *C. biru* fragments that were in contact with corals was highly toxic (very strong and strong) compared with extract from the control sponges (moderate and weak). The mushroom corals that were placed in contact with fragments of the three other sponge species remained tied in place for the whole experimental method.

Mobility of mushroom corals helps them to disperse and occupy vacant space, to avoid burial in soft sediments, and to escape competition with other corals (Chadwick 1988;

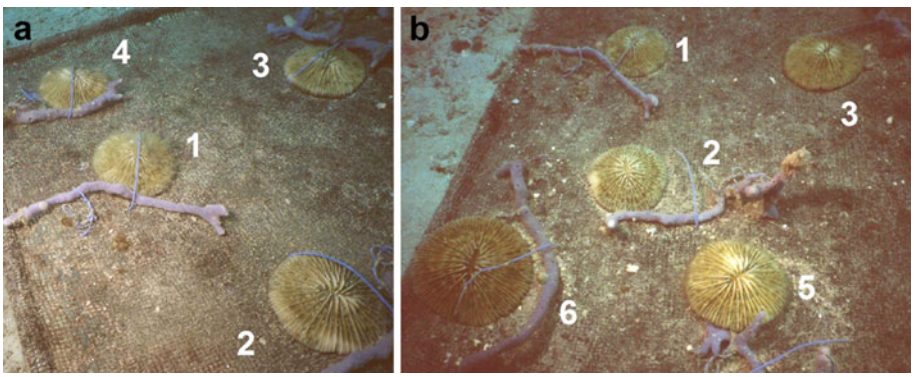

Fig. 1 *Heliofungia fralinae* corals in experimental set-up at Samalona I., Spermonde Archipelago. **a** Corals (∅ 12–15 cm) placed in contact with fragments of the sponge *Callyspongia biru* (start of experiment, T0). **b** Some corals are escaping, only number 1 remains fixed (T3)

Hoeksema 1988). In the present study, individuals of *H. fralinae* were able to unfasten themselves and move away from toxic sponges of the species *C. biru* and so survive.

In another confrontation experiment (de Voogd et al. 2005), where specimens of the mushroom coral *Fungia fungites* (Linnaeus, 1758) were placed in contact with fragments of *C. biru*, none of the fungiids escaped but some of them showed white spots. This suggests that exudation of secondary metabolites and competitive dominance of the sponge may elicit bleaching as a stress response in the corals. Although competition has not been explicitly seen to cause bleaching among corals (Brown 1997), there are indications that it may play a role in coral–algal interactions (McCook et al. 2001). *F. fungites* is known to be an aggressive competitor for space (Hildemann et al. 1975; Thomason and Brown 1986), but no such information is available for the less common *H. fralinae*. These two species are less closely related than has been previously assumed (Gittenberger et al. 2011).

This is the first report of mushroom coral movements caused by interaction with a non-coral invertebrate. *H. fralinae* has a subordinate role but little is known about interspecific interactions with other organisms. Parasitic and commensal animals have never been recorded from *H. fralinae*, in contrast to most other mushroom coral species, and in particular its congener, *H. actiniformis* (Quoy and Gaimard, 1833), one of the most hospitable coral species recorded so far (Bos 2011; Hoeksema and Fransen 2011; Hoeksema et al. 2011).

The capacity of *H. fralinae* to inflate its polyp, like *H. actiniformis* (see Abe 1939), may have helped the corals to wriggle free from the ties. Small individuals of the mushroom coral *Lobactis scutaria* (Lamarck, 1801) are able to flee from neighbouring corals by nocturnal polyp expansion and by pushing, while larger and heavier individuals remaining in contact with coral neighbours can inflict damage on their tissue by the secretion of mucus containing nematocysts (Chadwick 1988; Chadwick-Furman and Loya 1992). Large mushroom corals do not move fast although they may be able to right themselves (Hoeksema 1988).

Polyp inflation, which may help mushroom corals to free themselves from sediment after burial, may also serve as a dispersal mechanism. This may prevent them being overtopped in large aggregations (Hoeksema 2004). Because mobile corals may more frequently come into contact with other organisms, aggressive behaviour would be beneficial. *H. fralinae* corals are likely to survive interactions with other species, either because of their aggressive behaviour or their flight response.

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